JC08 Rec'd PCT/PTO 14 MAY 2001

U.S. APPLICATION NO. if known, see 37 C.F.R.1.5	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/831722	PCT/DE00/02877	10191/1728

17. ☒ The following fees are submitted:

	CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO .... $860.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) . . . . $690.00 No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) .... $710.00 Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO .... $1,000.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	23 - 20 =	3	X $18.00	$ 54	
Independent Claims	2 - 3 =	0	X $80.00	$ 0	
Multiple dependent claim(s) (if applicable)			+ $270.00	$ 0	

TOTAL OF ABOVE CALCULATIONS =	$ 914	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).	$	
SUBTOTAL =	$ 914	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +	$	
TOTAL NATIONAL FEE =	$ 914	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +	$	
TOTAL FEES ENCLOSED =	$ 914	
	Amount to be: refunded	$
	charged	$

a. ☐ A check in the amount of $__________ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 11-0600 in the amount of $914.00 to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0600. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

By: [signature] Reg No 35,952

SEND ALL CORRESPONDENCE TO:

[signature]
SIGNATURE

Kenyon & Kenyon
One Broadway
New York, New York 10004

Richard L. Mayer, Reg. No. 22,490
NAME

5/14/01
DATE

358308

26646
PATENT TRADEMARK OFFICE

09/831722

JC08 Rec'd PCT/PTO 14 MAY 2001

EXPRESS MAIL CERTIFICATE

"EXPRESS MAIL" MAILING LABEL NUMBER EL302704116US

DATE OF DEPOSIT 5/14/01

TYPE OF DOCUMENT US Nat. Phase Appln.

re Grosse et al.

SERIAL NO. to be assigned FILING DATE herewith

09831722 . 051401

I HEREBY CERTIFY THAT THIS PAPER OR FEE IS BEING DEPOSITED WITH THE UNITED STATES POSTAL SERVICE "EXPRESS MAIL POST OFFICE TO ADDRESSEE" SERVICE UNDER 37 CFR 1.10 ON THE DATE INDICATED ABOVE, BY BEING HANDED TO A POSTAL CLERK OR BY BEING PLACED IN THE EXPRESS MAIL BOX BEFORE THE POSTED DATE OF THE LAST PICK UP, AND IS ADDRESSED TO THE ASSISTANT COMMISSIONER FOR PATENTS, WASHINGTON, D.C. 20231.

Sunshine S.E. Limanni

(PRINTED NAME OF PERSON MAILING PAPER OR FEE)

Sunshine Limanni

(SIGNATURE OF PERSON MAILING PAPER OR FEE)

Device & Method for Producing a Local Plasma Through Microstructure Electrode Discharging Using Microwaves

09/831722

JC08 Rec'd PCT/PTO 14 MAY 2001

[10191/1728]

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s) : Stefan GROSSE et al.

Serial No. : To Be Assigned

Filed : Herewith

For : DEVICE AND METHOD FOR PRODUCING A LOCAL PLASMA THROUGH MICROSTRUCTURE ELECTRODE DISCHARGES USING MICROWAVES

Art Unit : To Be Assigned

Examiner : To Be Assigned

Assistant Commissioner
for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT AND
37 C.F.R. § 1.125 SUBSTITUTE SPECIFICATION STATEMENT

SIR:

Please amend the above-identified application before examination, as set forth below.

IN THE SPECIFICATION AND ABSTRACT:

In accordance with 37 C.F.R. § 1.121(b)(3), a Substitute Specification (including the Abstract, but without claims) accompanies this response. It is respectfully requested that the Substitute Specification (including Abstract) be entered to replace the Specification of record.

IN THE CLAIMS:

Without prejudice, please cancel original claims 1-22, and please add new claims 23-45 as follows:

EL302704116

23. (New) A device for producing a plasma through microstructure electrode discharges, a use of the plasma including at least one of treating surfaces, chemically reacting gases, and producing light, the device comprising:

at least one guide structure; and

a microwave generator, the microwave generator launching electromagnetic microwaves into the at least one guide structure to produce the plasma.

24. (New) The device of claim 23, further comprising at least one launching structure, wherein the launching structure links the microwave generator with the at least one guide structure.

25. (New) The device of claim 23, wherein the at least one guide structure is a metallic waveguide filled with a dielectric material, the dielectric including at least one of silicon dioxide, ceramic, and Kapton; and further comprising:

an arrangement of at least two spaced metal plates, the at least two spaced metal plates forming an interstitial space filled with a dielectric material.

26. (New) The device of claim 23, wherein the at least one guide structure is an arrangement of at least two spaced metal plates, the at least two spaced metal plates forming an interstitial space filled with a dielectric material.

27. (New) The device of claim 23, wherein the at least one structure is an arrangement of at least two metallic strip lines, the at least two metallic strip lines running on a dielectric plate.

28. (New) The device of claim 23, wherein the at least one guide structure is at least one of planar, curved, cylindrical and coaxial, the at least one guide structure including an internal, central conductor.

29. (New) The device of claim 23, wherein at least one of the at least one guide structure and an area surrounding the at least one guide structure has at least one plasma region.

30. (New) The device of claim 29, wherein the at least one plasma region is at least one cylindrical hole provided in the at least one guide structure.

31. (New) The device of claim 30, wherein the inner wall of the at least one cylindrical hole is provided with at least one of a dielectric coating and a ceramic protective layer.

32. (New) The device of claim 30, wherein the at least one cylindrical hole has a diameter of 10 μm to 1000 μm.

33. (New) The device of claim 30, further comprising a multiplicity of cylindrical holes, wherein the multiplicity of cylindrical holes are regularly spaced.

34. (New) The device of claim 25, wherein the metallic waveguide has a thickness.

35. (New) The device of claim 26, wherein the metal plates have a spacing of 10 μm to 1000 μm.

36. (New) The device of claim 25, wherein an H_{10} mode of the microwaves is launched into the at least one guide structure.

37. (New) A method for producing a spatially narrowly limited gas plasma comprising:

providing a microwave generator, the microwave generator coupled to a launch structure, the launch structure coupled to at least one guide structure;

launching microwaves through the launch structure into the at least one guide structure; and

supplying a gas, wherein the microwaves and the supplied gas produce a plasma in at least one plasma discharge region.

38. (New) The method of claim 37, wherein the supplied gas is directed through at least one cylindrical hole provided in the at least one guide structure, and the plasma is produced in at least one of the at least one cylindrical hole and an area surrounding the at least one cylindrical hole.

39. (New) The method of claim 37, wherein at least one of the supplied gas is directed past the at least one guide structure and the at least one guide structure is acted upon by the supplied gas, a plasma being produced in a plasma volume at a surface of the at least one guide structure at least on a region by region basis.

40. (New) The method of claim 37, wherein the plasma is produced at a pressure of 0.01 mbar to 1 bar.

41. (New) The method of claim 37, wherein a microwave power of approximately 1 mW to 1 watt is supplied to the at least one plasma discharge region.

42. (New) The method of claim 37, wherein the supplied gas is at least one of an inert gas, argon, helium, xenon, air, oxygen, hydrogen, acetylene, methane, a gaseous precursor material, and a vaporous precursor material.

43. (New) The method of claim 37, wherein the gas is supplied with a gas flow of up to 5000 sccm.

44. (New) The method of claim 37, wherein a frequency of the launched microwaves is between 300 MHz to 300 GHz.

45. (New) The method of claim 37, wherein the spatially narrowly limited plasma is located in the immediate vicinity of the surface of a substrate, and further comprising using the plasma for at least one of:

processing and activating at least one surface of the substrate for chemical reactions including exhaust gas cleaning;

producing light; and

depositing layers on the substrate.

REMARKS

This Preliminary Amendment cancels without prejudice original claims 1-22 in the underlying PCT Application No. PCT/DE00/02877, and adds new claims 23-45. The new claims conform the claims to U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.121(b)(3), the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. § 1.121(b)(3)(iii) and § 1.125(b)(2), a Marked Up Version Of The Substitute Specification comparing

the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) is respectfully requested.

The underlying PCT Application No. PCT/DE00/02877 includes an International Search Report, dated January 16, 2001. The Search Report includes a list of documents that were uncovered in the underlying PCT Application. A copy of the Search Report accompanies this Preliminary Amendment.

Applicants assert that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,

KENYON & KENYON

By: Reg No 35,952

Dated: 5/14/01

By:

Richard L. Mayer
(Reg. No. 22,490)

One Broadway
New York, NY 10004
(212) 425-7200

359287

1/PRTS

09/831722

[10191/1728]

JC08 Rec'd PCT/PTO 14 MAY 2001

DEVICE AND METHOD FOR PRODUCING A LOCAL PLASMA THROUGH MICROSTRUCTURE ELECTRODE DISCHARGES USING MICROWAVES

Background Information

The present invention starts out from a device and a method implemented therewith for producing a plasma, in particular for treating surfaces, for chemically reacting gases, or for producing light, by making use of microstructure electrode discharges according to the species defined in the independent claims.

When treating surfaces using a plasma method, it is advantageous for the plasma to be produced as closely as possible to the surface or substrate to be treated, or for a plasma source having a sharply defined or local plasma volume to be introduced in close proximity to the substrate to be treated. This is achieved in known methods heretofore by using so-called microstructure electrode discharges, provision being made for dielectric plates having electrodes that are typically disposed at a distance of approximately 100 μm or less from one another. As is generally known, discharges of this kind work within a very broad pressure range and exhibit relatively sharply delimited plasma interfaces, i.e., large-area, but locally narrowly limited, small-volume plasmas are produced.

Under the state of the art, microstructure electrode discharges have been exclusively ignited and operated by d.c. voltage. In this regard, reference is made, for example, to M. Roth et al., „Micro-Structure Electrodes as Electronic Interface Between Solid and Gas Phase: Electrically Steerable Catalysts for Chemical Reaction in the Gas Phase", 1997, 1st Int. Conf. on Microreaction Technology, Frankfurt/Main and J.W. Frame, „Microdischarge Devices Fabricated in Silicon",

1997, Appl. Phys. Lett., 71, 9, 1165. High-frequency or microwave excitations have not been implemented under known methods heretofore.

It is also known from Kummer, „Grundlagen der Mikrowellentechnik" [Fundamentals of Microwave Technology], VEB Publishers-Technology, Berlin, 1986, to direct microwaves via waveguides or strip waveguides (microstrip technology). In the case of the strip waveguides (microstrips), a metallic printed conductor, into which microwaves are launched, is usually applied to a dielectric substrate having a multiply grounded metallic base plate. In the case that there is more than one printed conductor running on the base plate, the metallic base plate can be eliminated.

Summary of the Invention

The device in accordance with the present invention and its associated method have the advantage over the related art of eliminating the need for the produced plasma to come into direct contact with the device producing the plasma, and, in particular, with the parts of this device being used as electrodes. This substantially prolongs the service life of the entire device in accordance with the present invention and, in particular, of the guide structure being used as microstructure electrodes. Moreover, the device in accordance with the present invention is clearly easier to service.

Moreover, due to the slight penetration depth of currents at high frequencies, the electrode material, i.e., the guide structure (metallic waveguide or strip waveguide) for guiding the launched microwaves in the device producing the plasma can be kept very thin, thereby substantially simplifying fabrication. Thus, at a frequency of 2.45 GHz, depending on the material used, the requisite thickness is merely a few μm. This applies as well for structures or components used for launching the microwaves into the guide structure. In

particular, the guide structure can, thus, be advantageously vapor-deposited, as well.

A locally or spatially narrowly bounded plasma is produced then by microwaves in one or preferably in a multiplicity of plasma regions that are isolated from one another, by a supplied gas, which is directed past or through the guide structure, or which acts upon the guide structure. Thus, a gas plasma is produced at the surface of the guide structure, at least on a region by region basis, in the plasma regions and in a plasma volume defined by these regions.

Further advantages and advantageous embodiments of the present invention are derived from the measures delineated in the dependent claims.

Thus, it is quite beneficial for the service life of the device, i.e., of the guide structure functioning as microstructure electrodes, for it to be coated with a protective dielectric layer in the vicinity of the plasma regions. Primarly suited for this are ceramic protective layers. The service life of the microstructure electrodes is significantly prolonged by this protective layer which cannot be used in a direct voltage operation.

Moreover, to fabricate the device, one can revert to existing technologies for generating plasma and, in particular, for guiding and discharging the launched microwaves in the guide structure. Thus, the microwaves are guided very advantageously via a known waveguide arrangement or a known micro-strip arrangement, which is produced and structurally configured using likewise generally known microstructuring methods.

The microwaves generated by a microwave generator are advantageously launched into the guide structure via at least one launching structure which communicates electroconductively with the guide structure. The frequency of the supplied microwaves amounts advantageously to 300 MHz to 300 GHz.

As part of the device for generating the gas discharge and, respectively, the plasma, the guide structure for the injected microwaves is very advantageously a metallic waveguide, which is filled with a puncture-proof dielectric material, such as silicon dioxide. However, the guide structure can also be constructed of an arrangement of at least two, preferably parallel spaced metal plates, whose interstitial space is filled in with a dielectric material. Due to its simpler structural design, as compared to closed waveguides, this configuration offers advantages from a standpoint of production engineering.

The waveguides, the metal layers of the waveguides, or the metal plates advantageously have a thickness, respectively a spacing, that corresponds to the penetration depth of the injected microwaves. Typical values, known, for example from Kummer, „Grundlagen der Mikrowellentechnik" [Fundamentals of Microwave Technology], VEB Technical Publishers, Berlin, 1986, are within the μm range, given a typical expansion in the length and/or width of the waveguides, i.e., of the metal plates, in the cm range.

A particular benefit is derived when the H_{10} mode of the launched microwaves is excited and guided in the waveguide, as a guide structure, since, in this case, it is merely the width of the waveguide that is critical for the propagation of the microwaves, and its length, for example, apart from unavoidable attenuation, can be varied substantially freely.

Alternatively, the guide structure can advantageously also be an arrangement made up of at least two metallic, in particular parallel strip lines, which run on a dielectric plate. Here, as well, silicon dioxide is suited, for example, as material for the plate. These strip lines are fabricated with a thickness of a few penetration depths, preferably using known microstructuring methods or microstrip structuring techniques.

In addition, provision is made in the vicinity of the guide structure for at least one, preferably however for a

multiplicity of plasma regions, which are advantageously produced by a microstructuring of the guide structure.

It is quite beneficial for these plasma regions to be cylindrical holes in the guide structure. Typical cylindrical hole diameters are advantageously about 50 μm to 1000 μm. They are expediently distributed in a regular arrangement in the vicinity of the guide structure. In the case of a waveguide as a guide structure, these cylindrical holes have the considerable advantage, in combination with the excited H_{10} mode, that the generated electrical field is aligned within the waveguide in parallel to the cylindrical holes and is substantially homogeneous. As a result, variations in field strength in the direction of the waveguide width are minimal in comparison to higher excitable modes.

To avoid or minimize surface stress or material ablation and accompanying gradual destruction of the plasma regions, i.e., of the guide structure by the generated plasma, the inner wall of the cylindrical holes and, optionally, the entire electrode surfaces as well, are advantageously provided with a dielectric, in particular ceramic protective layer. This dielectric protective layer only marginally degrades the propagation of the microwaves in the guide structure.

The plasma is advantageously produced in the plasma-generation regions at a pressure of 0.01 mbar to 1 bar, a microwave power of approximately 1 mW to 1 watt being advantageously supplied to the plasma regions via the microwave generator and the launching structure.

The supplied gas is preferably an inert gas, in particular argon, He or Xe, as well as air, nitrogen, hydrogen, acetylene or methane, that is preferably supplied with a gas flow of about 10 sccm to about 1000 sccm. However, in the individual case, these parameters are scaled down by the selected dimensional size of the device for producing plasma and are merely to be considered as typical values. Another significant benefit is that the device in accordance with the present

invention can be operated on exposure to air, thereby achieving an oxidic surface excitation. Moreover, the broad pressure range, from atmospheric pressure up to a precision vacuum, within which the work can be done, makes possible many diverse applications.

The device in accordance with the present invention and the method implemented therewith are especially suited for processing or activating the surfaces of a substrate or for depositing layers. Its special advantage lies, in this context, in the spatially narrowly limited extent of the plasma regions and in their immediate vicinity to the substrate surface to be treated.

Drawing

Exemplary embodiments of the present invention are elucidated on the basis of the drawing and elucidated in the following description. Figure 1 depicts a device including a guide structure having cylindrical holes; Figure 2 an alternative specific embodiment of the guide structure; Figure 3 a first gas guideway in the case of a plasma processing of a substrate using a guide structure; and Figure 4 an alternative specific embodiment including another gas guideway.

Exemplary Embodiments

Figure 1 illustrates a device 1 having a launching structure 10, a guide structure 11, and plama regions 12. In this case, launching structure 10 has the shape of a horn 20, as generally known from microwave technology, and is used for launching microwaves into guide structure 11. The microwaves are generated by a generally known microwave generator (not shown) which is linked to launching structure 10. Horn 20 passes electroconductively over into guide structure 11, enabling microwaves to be launched by microwave generator via launching structure 10 into guide structure 11.

In this example, guide structure 11 is designed as waveguide

21 of a metal, such as copper, high-grade steel, gold or silver, which is filled on the inside, for example, with silicon dioxide as puncture-proof and low-loss dielectric material 22. Waveguide 21 has a thickness of up to a few mm. Its length is variable, but should amount to one fourth of the wavelength of the injected microwaves. Its width is determined in accordance with the waveguide mode selected.

In addition, waveguide 21 is provided with a multiplicity of cylindrical holes 26, which are configured in a regular arrangement and which define plasma regions 12 located in the vicinity of cylindrical hole 26. The diameter of individual cylindrical hole 26 amounts to about 50 μm to 1 mm. Thus, device 1 is a microstructure, a plasma being ignited within each plasma region 12 of guide structure 11 subsequent to the supplying of a gas. Inner wall 23 of cylindrical holes 26 and, optionally, the entire electrode surfaces of guide structure 11 are also provided with a dielectric, in particular ceramic, coating as a protective layer, which is made, for example, of aluminum oxide or silicon dioxide.

The frequency of the microwaves launched into guide structure 11 is expediently between 300 MHz to 30 GHz; preferably between 900 MHz and 2.45 GHz are used. In this context, waveguide 21 is preferably dimensionally sized, and the frquency of the microwaves is preferably selected such that the H_{10} mode of the launched microwaves is excited in waveguide 21 and propagates.

For this, in the individual case, one skilled in the art must match the width of waveguide 21 and the frequency of the microwaves to one another. For excitation of the H_{10} mode, merely the width of waveguide 21 is a critical quantity, while it length, for example, is merely relevant to the attenuation of the propagating microwave. The power of the launched microwaves is additionally selected to yield a power of about 1 mW to about 1 watt for each plasma discharge region 12.

Figures 3 and 4 elucidate the operation of device 1 for

treating the surface of a substrate 30 with a plasma through the microstructure electrode discharges produced using device 1 in plasma regions 12 of guide structure 11. To this end, in accordance with Figure 3, a gas is directed via a gas supply line 31 from the side facing away from substrate 30 through cylindrical holes 26 of guide structure 11. Thus, this gas flows past the surface of substrate 30 and then off to the side. As of a minimal injected microwave power, which is essentially a function of the type of supplied gas, the gas flow, the pressure, and the thickness of waveguide 21, plasma is then generated in plasma regions 12 essentially defined by the extent of cylinderical hole 26. Thus, located between guide structure 11 and substrate 30, at least on a region by region basis, is a plasma volume 40, formed by various plasma regions 12, which are isolated from one another, depending on the spacing of cylindrical holes 26, or which have grown together.

The supplied gas is, for example, an inert gas, respectively a noble inert gas, such as nitrogen or argon, for cleaning or activating the surfaces of substrate 30. However, in the same way, it can also be a generally known reactive gas, such as oxygen, air, acetylene, hydrogen, or a gaseous or vaporous precursor material, such as an organic silicon or organic titanium compound. Depending on the selection of the supplied gas, chemical reactions can also be induced by device 1 at the surface of the substrate, or a surface coating can be provided, for example in the form of a hard material coating or wear-protection layer.

The plasma is produced in plasma region 12 with the aid of microwaves launched into guide structure 11 and with the supplying of a gas, depending on the dimensional design of guide structure 11, the type of supplied gas, the diameter of cylindrical holes 26, the width of waveguide 21, and the desired treatment of the surface at a pressure of about 0.01 mbar up to about 1 bar, each of which is to be determined in the individual case by one skilled in the art based on simple preliminary tests. Preferred is a pressure from 10 mbar up to

200 mbar, plasma gas being supplied with a typical gas flow of a few sccm up to about 1000 sccm. However, this value is likewise to be adapted by one skilled in the art to the particular process parameters for each case, after performing preliminary tests.

As a second exemplary embodiment, Figure 4 depicts an alternative routing of the supplied gas via gas supply line 31. In this context, the gas flows past, in between the surface of substrate 30 and guide structure 11, and is not fed through cylindrical holes 26. Apart from that, however, the parameters for producing the plasma in plasma regions 12 are completely analogous to the exemplary embodiment elucidated with the aid of Figures 1 and 3.

In a third exemplary embodiment, as a slight variation of waveguide 21, guide structure 11 is made of two parallel spaced metal plates, whose interstitial space is filled with silicon dioxide. Apart from that, guide structure 21 is constructed completely the first exemplary embodiment and Figure 1, especially with respect to dimensional design, cylindrical holes, and material. The advantage of using two parallel metal plates in place of waveguide 21 is that, from a standpoint of production engineering, they are simpler and less expensive to fabricate than a closed waveguide 21. In this case, the guidance and propagation of the launched microwaves is carried out by way of a capacitive coupling of the two plates. Analogously to the preceding exemplary embodiments, the gas is supplied in this exemplary embodiment in the manner explained with respect to Figures 3 or 4.

As a further exemplary embodiment, Figure 2 clarifies an alternative specific embodiment of guide structure 11, the launched microwaves being guided via strip lines 24 using microstrip technology. In this case, horn 20 is not necessary since the microwaves generated by the microwave generator are injected via coaxial plug connectors.

In detail, in this example, at least two, preferably however a

multiplicity of metallic strip lines 24 are applied to a dielectric plate 25, which is made of a puncture-proof material, such as silicon dioxide. These strip lines 24 expediently run in parallel to one another at a distance that is a function of the frequency and the dielectric material used, and are preferably made of copper or gold, which is optionally applied to a galvanic reinforcement, such as nickel. The optimal distance of strip lines 24 for igniting and sustaining a plasma in plasma regions 12 is additionally a function of the type of gas supplied and of the prevailing pressure and must, therefore, be determined in simple preliminary tests.

Furthermore, analogously to Figure 1, cylindrical holes 26 are provided in dielectric plate 25 between strip lines 24. With respect to the dimensional design of guide structure 11 and of cylindrical holes 26, reference is made to the preceding explanations regarding the first exemplary embodiment. In particular, in this case as well, cylindrical bores 26 can be provided with a dielectric coating 27, for example in the form of a ceramic protective layer, on inner wall 23. Cylindrical bores 26, in turn, define locally limited plasma regions 12, in which microstructure electrode discharges are ignited via the injected microwaves directed via strip lines 24 in response to the supplying of a gas or on exposure to air. When cylindrical holes 26 are arranged in a dense enough configuration, the plasmas produced in plasma regions 12 couple over, and a laterally homogeneous plasma develops.

In the case of a guide structure 11 in accordance with Figure 2, the gas guidance is completely analogous to the exemplary embodiments already explained and can be carried out in the manner explained with respect to Figure 3 or 4, in that the gas is directed through cylindrical holes 26 or conveyed between substrate 30 and guide structure 11.

Reference Symbol List

1	device
10	launching structure
11	guide structure
12	plasma region
20	horn
21	waveguide
22	dielectric material
23	inner wall
24	strip line
25	dielectric plate
26	cylindrical hole
30	substrate
31	gas supply line
40	plasma volumes

What is claimed is:

1. A device for producing a plasma, in particular for treating surfaces, for chemically reacting gases, or for producing light, through microstructure electrode discharges, using a device (1) for producing plasma, the device (1) having at least one guide structure (11),
wherein a microwave generator is provided, which can be used to launch / inject electromagnetic microwaves into the guide structure (11) to produce plasma.

2. The device as recited in Claim 1,
wherein the device (1) has at least one launching structure (10), and the microwave generator is linked via the launching structure (10) with the guide structure (11).

3. The device as recited in Claim 1,
wherein the guide structure (11) is a metallic waveguide (21), which is filled with a dielectric material (22), in particular silicon dioxide, ceramic, or Kapton.

4. The device as recited in Claim 1,
wherein the guide structure (11) is an arrangement of at least two, in particular parallel spaced metal plates, whose interstitial space is filled with a dielectric material (22), in particular silicon dioxide.

5. The device as recited in Claim 1,
wherein the guide structure (11) is an arrangement of at least two metallic, in particular parallel strip lines (24), which run on a dielectric plate (25), in particular on a substrate of silicon dioxide.

6. The device as recited in Claim 1,
wherein the guide structure (11) is planar or curved and, in particular, has a cylindrical or coaxial form, including an internal, central conductor.

7. The device as recited in Claim 1,

wherein the guide structure (11) or its surrounding area has at least one plasma region (12).

8. The device as recited in Claim 7, wherein the plasma region (12) is a cylindrical hole (26) provided in the guide structure (11).

9. The device as recited in Claim 8, wherein at least the inner wall (23) of the cylindrical hole (26) is provided with a dielectric coating, in particular a ceramic protective layer.

10. The device as recited in Claim 8, wherein the cylindrical hole (26) has a diameter of 10 μm to 1000 μm.

11. The device as recited in Claim 8, wherein an especially regular arrangement of a multiplicity of cylindrical holes (26) is provided.

12. The device as recited in Claim 3 or 4, wherein the waveguide (21) has a thickness, respectively the metal plates have a spacing of 10 μm to 1000 μm.

13. The device as recited in Claim 3, wherein the H_{10} mode of the launched microwaves is directed in the guide structure (11).

14. A method for producing an especially spatially narrowly limited gas plasma using a device in accordance with at least one of the preceding claims, wherein the microwaves are launched via a launching structure (10) and then via a guide structure (11), and, together with a supplied gas, the guided microwaves produce a plasma in at least one plasma region (12).

15. The method as recited in Claim 14, wherein the gas is directed through cylindrical holes (26)

provided in the guide structure (11), and the plasma is produced in the cylindrical hole (26) and/or in an area surrounding the cylindrical hole (26).

16. The method as recited in Claim 14 or 15, wherein the supplied gas is directed past that guide structure (11) or this structure is acted upon by the supplied gas, so that, at least on a region by region basis, a plasma is produced in a plasma volume (40) at the surface of the guide structure (11).

17. The method as recited in Claim 14, wherein the gas plasma is produced at a pressure of 0.01 mbar up to 1 bar.

18. The method as recited in Claim 14, wherein a microwave power of, in each case, approximately 1 mW to 1 watt is supplied to the plasma discharge regions (12).

19. The method as recited in Claim 14, wherein an inert gas, in particular argon, helium or xenon, air, oxygen, hydrogen, acetylene, methane, or a gaseous or vaporous precursor material is supplied as a gas.

20. The method as recited in Claim 14, wherein the gas is supplied with a gas flow of up to 5000 sccm.

21. The method as recited in Claim 14, wherein the frequency of the supplied microwaves amounts to 300 MHz to 300 GHz.

22. A use of the device and of the method implemented therewith as recited in at least one of the preceding claims for processing or activating the surfaces of a substrate (30), for chemical reactions, in particular in exhaust gas cleaning, for producing light or for depositing layers on the substrate (30) using a plasma, in particular within a spatially narrowly limited plasma volume (40) located in the immediate vicinity

of the surface of the substrate (30).

Abstract

A device is proposed for producing a plasma, in particular for treating surfaces, for chemically reacting gases, or for producing light, by way of microstructure electrode discharges, using a device (1) for producing plasma having at least one guide structure (11). In addition, a microwave generator is provided, which can be used to launch microwaves into the guide structure (11). Moreover, the guide structure (11) has at least one, in particular locally narrowly limited plasma region (12), which is in contact with a gas. The guide structure (11) is preferably a metallic waveguide (21), which is filled with a dielectric material (22), or an arrangement of strip lines which run on a dielectric plate. The device and the method implemented therewith are particularly suited for processing or activating surfaces or for depositing layers on a substrate.

Figure 1

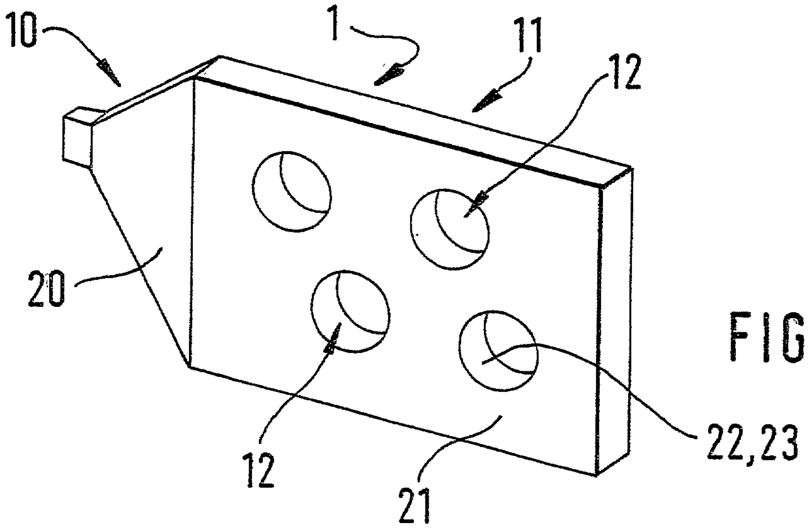

FIG.1

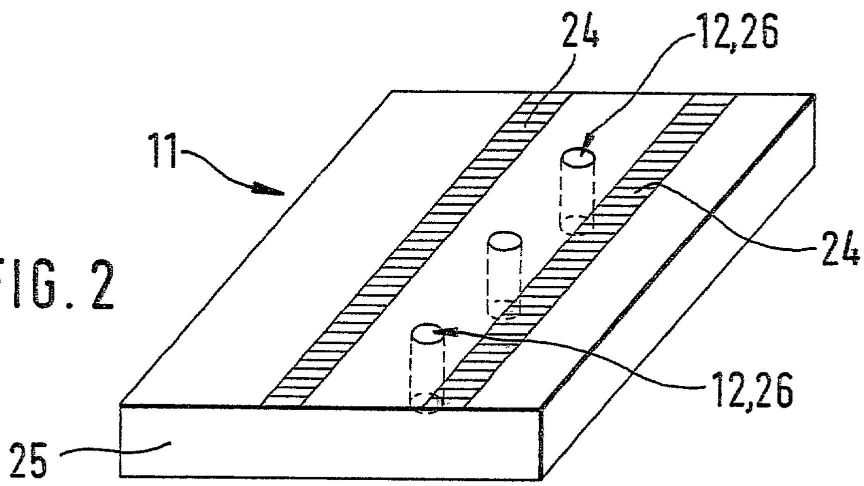

FIG.2

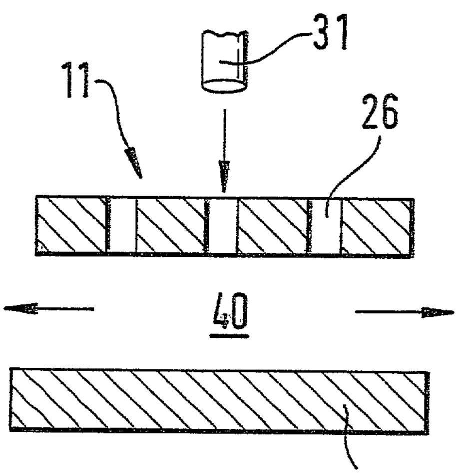

FIG.3

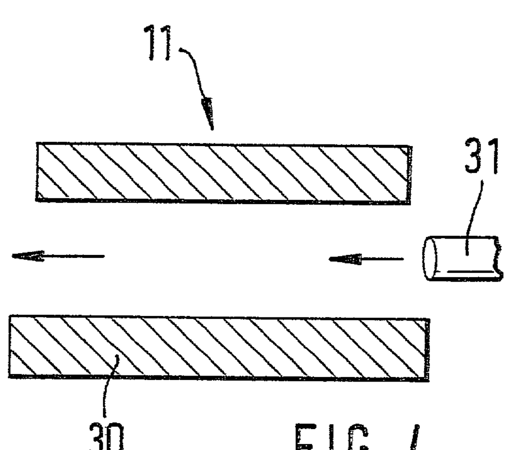

FIG.4

[10191/1728]

<u>**DECLARATION AND POWER OF ATTORNEY**</u>

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **DEVICE AND METHOD FOR PRODUCING A LOCAL PLASMA THROUGH MICROSTRUCTURE ELECTRODE DISCHARGES USING MICROWAVES**, the specification of which was filed as PCT/DE00/02877 on August 23, 2000.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

EL302704446

EL039793589US

PRIOR FOREIGN APPLICATION(S)

Number	Country filed	Day/month/year	Priority Claimed Under 35 USC 119
199 43 953.2	Fed. Rep. of Germany	14 September 1999	Yes

And I hereby appoint Richard L. Mayer (Reg. No. 22,490) and Gerard A. Messina (Reg. No. 35,952) my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

Please address all communications regarding this application to:

KENYON & KENYON
One Broadway
New York, New York 10004

26646
PATENT TRADEMARK OFFICE

Please direct all telephone calls to Richard L. Mayer at (212) 425-7200.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful and false statements may jeopardize the validity of the application or any patent issued thereon.

Inventor: **Stefan GROSSE**

HW

Inventor's Signature: S. Grosse

Date: 05/28/2001

Residence: Meterstraße 4d
70839 Gerlingen
Federal Republic of Germany DAY

Citizenship: Federal Republic of Germany

Post Office Address: Same as above.

JV

Inventor: **Johannes VOIGT**

Inventor's Signature: Dr. J. Voigt

Date: 05/30/2001

Residence: Stoeckhofstraße 47
71229 Leonberg
Federal Republic of Germany DEX

Citizenship: Federal Republic of Germany

Post Office Address: Same as above.

09806224.053101

358470